BOREAL INSTITUTE
LIBRARY

POSITION PAPER

The Arctic Institute of North America

United Nations Conference on the Human Environment Stockholm, June 1972

POLAR
PAM
2840
POLARPAM

Pam: 577.4: (*3)
AINA

THE ARCTIC INSTITUTE OF NORTH AMERICA

POSITION PAPER

prepared for the

United Nations Conference on

the Human Environment

Stockholm, June 1972

08000

BOREAL INSTITUTE
LIBRARY

AUG 1 4 1972

copyright: The Arctic Institute of North America, 1972

FOREWORD

In May 1971, the Board of Governors of the Arctic Institute of North America decided that the Institute should make a contribution to a conference on the human environment, to be organized by the United Nations, and planned for Stockholm, 1972. A working group was organized to write a paper, under the chairmanship of Dr. M.J. Dunbar, Director, Marine Sciences Centre, McGill University. Its members included Institute Governors Dr. W.S. Benninghoff (University of Michigan), Dr. John Martin Campbell (University of New Mexico), and Dr. E.F. Roots (Coordinator, Polar Continental Shelf Project, Government of Canada).

After several drafts were considered by members of the working group, a paper was produced and sent to the Secretary-General of the Conference, Mr, Maurice Strong. Because of the deadline for papers set by the United Nations Secretariat, the paper was submitted before the Institute's Board gave its final approval to the paper. On 4 December 1971, however, the Board reviewed the paper and accepted it, with minor revisions, as an Institute position.

The document which follows is the revised paper, as approved by the Board.

H.W. Love

Executive Director
The Arctic Institute
of North America
January 1972

THE ARCTIC INSTITUTE OF NORTH AMERICA

POSITION PAPER

THE ARCTIC INSTITUTE OF NORTH AMERICA

POSITION PAPER

Introduction

For two years, 1914-1916, Dr. Diamond Jenness, pioneer Canadian anthropologist, lived and worked among the Eskimos of the Western Arctic, and in 1928 produced a book, People of the Twilight, which remains a classic of its kind. The last sentence in that book is in the form of a question: "Were we the harbingers of a brighter dawn, or only messengers of ill-omen, portending disaster?" Fridtjof Nansen, in writing a preface for the book, referred to this passage and closed with: "The problem must be faced, but at once and with intelligent prudence, unless it shall be too late." Since 1928 the career of commercial man in the North American Arctic has not been outstanding for its intelligent prudence, nor has that of Government. Dr. Jenness's question has not yet been answered, but the answer is now hanging over us, to fall one way or the other, and furthermore it will affect not only the Eskimo (and Indian) people, but the future of the north as a whole, its development and its value, and its population as a whole. Industry on a quite new scale has now entered the northern scene. To put it in current biological jargon, the ecosystem is about to be stressed.

The Arctic Institute of North America has been aware of this problem and this danger since its foundation in 1945; in fact much of the work supported by the Institute has been directed, in the long or short term, to the well-being of the Arctic environment. Some of the landmarks in this work are: The "Arctic Research" volume of Arctic (vol. 7, nos. 3 and 4, 1955); the Proceedings of the Arctic Basin Symposium at Hershey, October 1962 (AINA, 1963); the Arctic Drifting Stations Symposium, 1966 (AINA, 1968); the special volume of Arctic (vol. 22, no. 3, 1969), on the work of the U.S. Naval Arctic Research Laboratory at Point Barrow, Alaska; the Proceedings of the Arctic and Middle North Transportation Conference, 1969 (AINA, 1969); the Proceedings of the Polar Plan Conference in October 1969 (AINA, 1969); and the Rensselaerville Conference, 1970, on Arctic Research and Resource Development (AINA, 1970). At the Toronto Workshop on Canadian-United States Maritime Problems, Dr. M.E. Britton of the Arctic Institute contributed an exhaustive report on "Special Problems of the Arctic Environment." Finally, the Institute has at present two on-going projects directed at environmental problems in the north: "Man in the North" and "Arctic Development and the Environment."

Historical

Man is an animal of tropical origin, and in accepting the "Toynbee Challenge" (out of Africa, through the Mediterranean, and to points east, west, south, and north) he has had to become adapted to temperate and polar conditions by the fast route, namely the exercise of his brain and the development of technology. The Eskimos, often considered "primitive" people by the world to the south, have developed the most perfect technological ability by which to form part of the Arctic ecosystem at their own non-industrial level. Their clothing was ideal, and both the clothing and the housing were nicely adjusted to the demands and resources of the environment. The seasonal oscillation and the behaviour and growth rates of the animal populations upon which they depended for a living were adjusted to by the development of a nomadic habit and a fairly loosely organized and small-community unit. The social and reproductive economy of the Eskimos was also well adapted to the natural situation. A basically communistic way of life ensured the survival of the maximum possible number in any unit under conditions in which the food supply was often very unreliable. The Eskimo was, in fact, his brother's keeper. On the other side of the coin, if the community were close to starvation, selective gerontocide and infanticide, even cannibalism, were resorted to.

Such practices are not accepted without demur by civilized man, although we condone equally savage habits every day in our own way of life; and the control and alteration of this ancient Eskimo system, which stayed nearly in balance with nature and was in fact part of nature, was imposed upon it from the outside, by the invasion into the north of a number of new phases of humanity. These phases are, more or less in order of appearance: Explorers, whalers, traders, missionaries, Government officials and agents, prospectors, scientists, miners, military, oilmen. Each phase has had, or is having, its own impact on the north.

In the present context the explorers do not concern us. It is with the traders and whalers that the first real contact between native people and new arrival appears. The whalers met the native population when they came ashore, and when the Eskimos came on board, and clearly there was social coming and going on such occasions, a little gene flow, and some transmission of disease. Only the last can be seriously considered as regrettable, and even that, in its inevitability, is not something for which the whalers themselves can be blamed; it was the result of the simple contact between two groups of human beings that had hitherto been separated. On the social level, the Eskimos and the whalers had considerable regard for the skills and traditions of the other, and this is always a very important point. Each learned from the other.

On the other hand, the whaling industry did do damage to the whale stocks themselves, and in doing so depleted a resource which was

important to the indigenous people. The hunt for the most important large species, the Greenland whale or Bowhead, stopped in the second decade of this century, and since then the whale population has shown definite signs of recovery. It is quite likely that these particular whales will again be used by the Eskimos.

The development of trading settlers, or trading settlements, was the first definitive and lasting novelty in the old system. It gave a value to the fox and farther south, the beaver, which the Eskimos and Indians could not have dreamed possible, and it introduced, as the years went by, tea, coffee, the rifle, flour, textiles and tobacco, steel knives and sugar, good boats and engines, wooden houses, aircraft, and radio, and much of the rest of our technological stock in trade. To control the effects of these novelties, and to balance the interests of natives and immigrants, Government departments and their agents moved in, and missionaries. Government in due course, and rather slowly, began to finance scientific research in the north, when it began to become clear that the north had great resources and that there were urgent scientific problems to be studied and solved before rational development could take place. This is the stage we had reached a few years ago with a not inconsiderable scientific achievement which made it possible to face the new situation: Oil and greatly stepped up mineral development in general. The two points of sharp focus now are (1) the preservation of the environment and (2) the adjustment of the indigenous population to the new situation.

Industry in the North

It must be recognized from the start that the north needs industrial development and that it will get it. It has been made clear that the cries of the extreme conservationists, or "apocalyptic ecologists," are somewhat resented by many of the residents of the north as being one-sided and biassed, and as not taking into account the economic needs of the northern people themselves. In this they are saying much the same as many developing countries who take exception to being expected to handicap their industrial development because the developed countries are now suffering from environmental pollution resulting from their own industry. This is indeed a strong point, and it emphasizes also something that seems to be generally overlooked, namely that the northern regions stand in relation to the large "Arctic landlords" (Canada, U.S.S.R., U.S.A., Denmark) much as colonies did to the colonial powers under the old system. The problems for the Governments concerned are of the same sort.

At the same time, there is also strong opinion in the north that environmental values, that is to say economic renewable resource values, require stringent protection, and that the harvesting of non-renewable resources must not be done in the reckless spirit of "development at any price."

It follows that the ground rules for environmental conservation in the north are the same as in any other part of the world. In the north we have the advantage of attacking these problems at the beginning, before the damage is done; this is an enormous advantage and should be used with the "intelligent prudence" urged by Fridtjof Nansen in 1928.

Apart from matters special to the Arctic and Subarctic, discussed below, the problems involved are primarily not scientific at all, but economic, legal, and social; most of the scientific solutions to environment damage are well known, and could be applied at any time. In a recent paper on industry in the Arctic environment, Mr. A. Hemstock, speaking in the Canadian context, had the following to say:

> The petroleum industry's prime responsibility is to supply Canadians with the energy chemicals they need, at the lowest possible cost and with the least possible disturbance to other life factors. The effects of disturbing the environment--the Canadian scene--often cannot be measured in dollars, and Canadians--especially younger Canadians--will not accept dirty rivers, scarred landscapes, or polluted air. Yet if we want to go on using packaged goods, and growing foods or producing minerals for ourselves and others, we must face at least some disturbance of our environment, some alteration of our air, land, and water from their natural state. Canadians must decide what their priorities are and what balance they really want between nature and technology. If we increase our use of resources, or even stay at our present level, the best intentions and the strictest of regulations cannot wholly prevent an adverse effect on the environment. What we must do is stop unnecessary damage, and develop methods and procedures that will prevent most serious accidents, and will lessen the impact of any that do occur. (Hemstock, 1971, quoted from Dunbar, 1971)

The establishment of the Prudhoe Bay oil rigs in Alaska, the finding of gas and oil in the Canadian Arctic, and the probability of other mineral discoveries and development, now face the north with industry on a scale that is quite new. It is not necessary to list the developments and the capital cost in detail. (For a recent account of oil field potential in Arctic North America, see Rempel, 1970.) What is necessary is to consider how they are likely to affect the ecosystem and the people, and how a balance between exploitation and destruction can be achieved.

Industry and the Ecosystem

1. The Land. On the subject of Arctic terrain and oil field development, Rempel (1970) writes as follows:

> Land portions of the sedimentary basins in Canada north of Latitude 60°... comprise about 470,000 square miles. It has been estimated that the development of the oil reserves in this region

will require the direct use of 1,350 square miles or not quite 0.3 percent of the total. This includes seismic lines, well sites, roads, pipelines, camp sites, storage dumps and airfields. About 1/3 of the land requirement is for seismic work and wildcat wells which is a temporary use, after which a considerable portion will revert to the original stage. The effect of this work on Arctic terrain will depend to a large measure on the amount of ice in the permafrost soils. Fine-grained frozen soils are particularly susceptible to disturbance by natural and artificial forces. The Norman Wells oil field, which lies near the southern limit of continuous permafrost, is a good starting point in a discussion of effects of oil field developments on arctic terrain.

Mr. Rempel goes on to point out that in the Norman Wells area, which is south of the tree-line, after 50 years of activity there is now little evidence of terrain degradation. "Tundra terrain, on the other hand, may be more sensitive to man's intrusion." Tundra terrain may indeed be more vulnerable, but we do not yet know much about this aspect of the tundra. There is, however, no doubt that scars made on the tundra, especially in summer, by bulldozers and other heavy vehicles, remain unhealed for a very long time, perhaps never recover fully, owing to the destruction of the permafrost base. How important this is esthetically is a matter of personal values; how important it is ecologically and economically remains to be discovered.

We are constantly being told, usually by politicians who have seen the ecological light, that the ecosystems of the Arctic are "delicate" or "fragile." Again, this remains to be seen, and experimental work on the question is badly needed. It is true that Arctic ecosystems are simple, in the sense that they contain far fewer species, and therefore fewer specific energy paths, than do the ecosystems of temperate and especially tropical regions; and it might follow that they are therefore more vulnerable to stresses of various kinds, and tend to go into violent oscillation which can lead to extinction. But it still is not known whether the activities of man could put greater stress upon the system than is the natural result of its own simplicity. Clearly the extinction of species is dangerous in a simple system, and there are species in the north which are threatened with extinction by industrial pollutants, notably the falcons; the present caribou herds may be seriously disturbed by human activities in settlement and development, and rich biotic complexes at deltas and in estuaries are threatened by drainage and water diversion. In other cases, there are threats of long standing concerned with over-hunting or over-fishing rather than with industrial development of the kind we are considering here. The guards against specific extinction are also of long standing, and apply to the north as they apply elsewhere.

The chief "oscillator" of the tundra ecosystem is the lemming; as the primary herbivore, it has large reproductive potential and is the focus of attention of several carnivores. Its population oscillates

with large amplitude in a period of from 3 to 5 years, and in years of low population it is often to all intents and purposes extinct locally; that is, in a given area it may be totally absent, which means that the carnivores must remove themselves or die off, and the whole system breaks down temporarily. But the system in the large scale nevertheless survives, and the lemmings reappear, no doubt by invasion from adjacent regions less drastically affected.

This suggests that in fact the system is much tougher than is popularly supposed, and it is as yet an open question whether oil development could do more than the system itself does in its natural oscillation. Certainly there is very little chance of the extinction of the lemmings, so long as they have free range over very extensive territories. Reducing the available areas for local populations may stress many wild species just as surely as degradation of the environmental quality of the total area. The important point is that there are unanswered questions here, for which we need speedy answers. How does the system respond to this kind of assault? Do oil production and transport pose a real threat to the long-term stability of the ecosystem? Are there species which might be threatened with extinction by industrial settlements in the north?

Research on these questions is being undertaken at present, by Government and by the oil industry itself, and useful answers can confidently be expected well before the expected date of the beginning of the shipment of oil southwards. The most interesting of all these problems, however, that of the resilience of the ecosystems themselves, will take longer and will not be easy to attack. Probably the best start can be made by a theoretical approach, by mathematical models and their manipulation, to be followed by testing on selected areas in the field.

The transport of oil from the Arctic is a matter which has engendered a great deal of heat in recent years. In permafrost country it is clear that it is not practical to bury pipelines underground, for several reasons. To build them above ground presents problems of different kinds: How are they to be supported on permafrost terrain? Will they disturb the migration of caribou? If they are to be covered in "berms," where is the necessary gravel to come from? (the most obvious answer is river bottoms, which would be almost certainly disastrous to fish populations; it has even been suggested that the pipelines should be put in the rivers themselves). If oil is taken by sea in a shuttle service from Valdez in south Alaska to the south, what about the risk of oil spill damage to the coasts of the Alaskan Panhandle and British Columbia?

Answers to these questions are urgently needed. Already certain general rules are appearing, such as the importance of keeping the permafrost layer intact, of working as much as possible in winter, and of curing mankind of his basic messiness, which is perhaps an inheritance from ancient nomadic days. At all events, the habit of strewing garbage

over the north is of long standing, as elsewhere in the world. Another and rather obvious general principle is the significance of the slow growth of organisms in cold climates. Trees may take over a century to reach a breast-height diameter of four inches; recovery from fire and deforestation is extremely slow. Arctic char may take twelve years to reach maturity; if a lake is fished out, which can be done in a year or two quite easily, it may be fifty years before the fish populations are fully restored, given complete protection from fishing. This rule of slow growth means simply that the control of the use of renewable resources in the north has to be even more carefully enforced than in warmer regions; otherwise the principles are the same.

In February 1970, the Canadian Wildlife Federation prepared a statement on the "Crisis in the North" which called for a moratorium on oil and other mineral development in the north until scientific research had caught up. We quote from that statement here (Passmore, 1970):

> A partial moratorium, lasting until 1974, would do much to bridge the serious knowledge gap which now exists. It would allow time for:
> 1. Completion of government-sponsored ecological research now being carried out by Canadian universities.
> 2. Development of new techniques, or modification of existing ones, for exploration, development, and production without excessive damage.
> 3. Ecological research to establish the levels of disturbance which can be tolerated in the different zones to be explored.
> 4. Testing the feasibility of transport of oil through Arctic waters by tanker or submarine.
> 5. Conducting research into the effect of oil spills on land and at sea, under Arctic conditions, and development of techniques for accomplishing the degree of clean-up indicated by that research.
> 6. Development of stand-by facilities, equipment, and staff necessary to ensure adequate clean-up in cases of accidental oil spills.
> 7. Studying the feasibility of permitting offshore drilling under the conditions of ice, wind speed, and temperature prevailing in the Arctic.
> 8. Training Indians and Eskimos in the skills used in all phases of exploration, development, and production of oil, so that native people may play a significant role in helping to develop their country.

The response to this call for a moratorium, on the part of the Government, was less than hoped for and much less than the situation probably demands, in the opinion of the ecologists concerned. Certainly

it is necessary to keep up the pressure for concentrated study of these problems. Those dealing with the Eskimos and Indians, and the sea, are discussed below.

2. Lakes. Arctic lakes are young, poor in nutrients, often very stable vertically (thermally) and therefore hard to turn over, and cold. They are therefore oligotrophic, or low in productivity. As mentioned above, the slow growth rates of living organisms at these low temperatures, and with these low food supplies, make Arctic lakes and rivers very vulnerable to over-fishing. The naturally low nutrient capital, or concentration of fertilizers such as phosphates, nitrates, silicates and other substances, invites experimentation and probably gives to the danger of "eutrophication" a somewhat different colour from the normal. One would suppose that controlled eutrophication in these waters might not in fact be a bad thing at all. Work is needed along these lines. Already there are interesting discoveries. On Cornwallis Island, in the vicinity of Resolute Bay, there are two lakes, Meretta Lake and Char Lake, one of which is in the water system of the settlement and therefore collects discharge from it, the other of which is not. Productivity in the former is now an order of magnitude higher than in the latter (Rigler 1971, Kalff et al., in press).

Arctic lakes, in all probability, form the most sensitive part of the natural system, to pollution of all sorts. In many, controlled eutrophication may well be advantageous, but all of them must be expected to be easily damaged by poisons, including pesticides. Many Arctic lakes harbour only one species of primary herbivore (a copepod crustacean), and one species of primary carnivore (usually a Mysid or an Amphipod). These are extreme cases of ecosystem simplicity, in which the removal of one species means the removal of one whole link in the food chain and therefore ecological disaster. Copepods in small lakes are far more vulnerable than lemmings on the vast northern tundra.

3. Sea water. The Arctic Ocean is part of the "world ocean," with massive exchange of water with the Atlantic and to a lesser extent with the Pacific. It is therefore as vulnerable to pollution as is any other part of the seas of the world, and it is not the purpose of this paper to treat the whole large matter of marine environmental damage. There is now a considerable literature on the general subject. There are, however, problems of the marine environment which are peculiar to the polar regions, some of them peculiar to the Arctic.

We quote here from a recent introduction to the subject of environmental damage in Canada (Dunbar, 1971):

> The question of oil spills in the sea is a specialized field demanding a whole book in itself. As far as the Arctic waters are concerned, there is every probability that the hazards will be complicated by the presence of the ice. The most toxic elements in crude oil are the most volatile: in more temperate seas they disappear

reasonably rapidly, but in the near-freezing-point temperatures of the Arctic they would be expected to dissipate much more slowly. As to the ice, oil very easily forms thick films on solid surfaces, so that the mess it would make on and beneath sea ice can well be imagined. Crude oil has a density between that of sea water and that of ice, so that it would accumulate and spread out just under the ice; this again would prevent the volatilization of the lighter parts. Finally, the process of degradation of oil in the sea by microorganisms would probably be greatly slowed in the Arctic; little is yet known about how the low temperatures would affect the emulsion formation (oil-in-water emulsion and water-in-oil emulsion) which determines the behaviour of oil in temperate waters.

Add to this the enormous size of the proposed tankers and the fact that the "Manhattan" suffered two large punctures in her hull in 1969--a light ice year and at the best season of the year for ice navigation--and it is not surprising that Arctic ecologists and Arctic administrators are worried.

In 1970, it was announced that the plan to use the sea route to take oil from Alaska through the Northwest Passage had been abandoned in favour of a pipe-line south through Alaska. Arctic marine ecologists can therefore breathe a little more easily for a while, at least until submarine tankers are given serious consideration.

Some study has been made of methods of treating crude oil in Arctic sea water, and some estimations have been made of its behaviour; the latter needs much more study. Experiments on the burning of crude oil on ice, and on water surfaces of small area contained by ice, appear to have shown that if the oil is caught before it has a chance to mix with the water, a process which is slowed down by low temperature and by the physical effects of the ice itself, the oil can be burned off fairly successfully. The importance of the lack of mixing has been underlined by the fact that in Chedabucto Bay, Nova Scotia, the site of the "Arrow" spill in February 1970 (near-Arctic conditions), it was found to be impossible to burn the oil at the sea surface. It is estimated, further, that crude oil would spread very slowly on Arctic water, especially in the presence of ice, and that the layer formed might be up to one foot in thickness.

The effect of any large oil spill in the Arctic can thus be expected to be very messy, and the damage, at least to the larger fauna, very serious. The seals, polar bears, walrus, ducks, murres, terns, and other species would be certain to suffer severely. The rest of the fauna and flora might be less disturbed, but it must be emphasized that no work has yet been done on this. Oil is to a large extent a surface danger, and there is virtually no intertidal invertebrate fauna in the true Arctic ("high Arctic"), because the inter-tidal zone is scraped

and eroded by the ice. The damage to the plankton, however, is problematical. If the light supply were significantly cut down over large areas, the effect might well be serious.

The effect on the birds and mammals is a dismal prospect, and should not be allowed to happen. "They are the most valuable production of the Arctic seas, and the Eskimos have depended upon them for centuries. Without them, the Eskimos as part of the ecosystem would disappear--a good example of the effect of damaging one part of a simple system of this sort" (Dunbar, 1971). Perhaps the Eskimo as part of the old ecosystem will disappear anyway, to move into the new, and perhaps this is desirable. This is a value decision which is discussed again below; but the birds and mammals are a highly useful and essential resource anyway, no matter what form the human culture takes in the developing north.

In considering damage to the marine biota, another characteristic of the Arctic scene should be remembered, as in the case of lakes and forests: the slow growth rates. Planktonic species, for example, of wide distribution in Arctic and temperate waters, may form successive breeding stocks five or six times in a single summer in the English Channel, only one per year in the Gulf of St. Lawrence, and may take two or even three years to achieve breeding maturity in Arctic water proper.

Pollution of the sea by metallic ions, thermal pollution, pesticides and other poisons, and radioactive substances, offers the same range of problems as in other seas, and is not given special treatment here. The pouring of plant fertilizers into the Arctic Ocean, which is improbable anyway, might well, on the other hand, be beneficial. The Arctic water (the term is used here to refer to true Arctic water originating in the upper layer of the Arctic Ocean, not to the mixed Subarctic waters) is very poor in these nutrients.

4. The Arctic atmosphere. There are no boundaries in the atmosphere --except those that may be inherent in the circulation itself, and they are not real obstructions to a through mixing over latitudes and longitudes (and height), given sufficient time. It is therefore observed that the increasing atmospheric CO_2 content is discernible over the Arctic Ocean as well as in all other latitudes. The Arctic is already affected by man's activities far outside its borders. The rapid transport into the Arctic of air from lower latitudes was seen, for example, by a three-fold jump in CO concentration at a station on the Greenland Icecap reported by Robinson and Robbins (1969). The event could be traced to contaminated air traveling in four days from northeastern U.S.A. to northern Greenland.

The main concern in the following will be with particular atmospheric problems arising from man's increasing activities within the Arctic.

Having stated that there are no boundaries in the atmosphere, it is useful to note that there are, nevertheless, certain conditions which may prevent a ready and rapid mixing of the air. In the Arctic one such condition is the frequent and widespread temperature inversion near the ground. There is, generally, a deficit of heat at the surface causing the lowest temperature to occur there. This is an inversion--highly stable and a formidable obstruction to vertical mixing. In summer it is less well developed and mainly seen near the north coast of Alaska and over the Beaufort Sea. The circumpolar land surfaces are then fairly warm and overlain by unstable air, causing effective mixing of a deep layer of the lower atmosphere. Not so in the winter, however. Then drastically different conditions prevail: a temperature difference of ten degrees and more occurs between the cold surface and the warmer air at 1500 m or so. The Siberian side of the Arctic shows a frequency of over 90% with such winter inversions, and 60% to 70% of the time sees such stable conditions on the American side (Vowinckel and Orvig, 1967).

A source of pollutant emission (whether water vapour, combustion, industrial) in such a stable environment will change its own local conditions for protracted periods, as exemplified by the ice fog problem at Fairbanks. An additional concern must be how far away the results of such local activities can be carried. There are several indications of the scale involved. The transport of smoke from forest fires has been reported in various places--smoke from western Canada has reached Europe, and Scandinavian forest fires have given smoke and haze layers at Svalbard (Spitsbergen). A report from the Canadian north indicates that even the individual smoke plume identity was maintained well over 30 km from the source (Peterson and Drury, 1967).

It would seem that the Arctic atmosphere carries a double burden: It is part of a whole and must share in the general state, but it also must bear such additional charges as may be imposed on it for a long, cold period each year. Added to the effect of the surface inversion is the wintertime phenomenon of the "polar-night westerlies" which reach from the troposphere into the stratosphere and form a circumpolar westerly wind system which will readily spread Arctic pollution over a broad area in high latitudes.

Precipitation will carry to the ground, within the Arctic, such tropospheric materials which have been deposited in the air at high latitudes. As much of the land area north of the tree-line is covered by a type of vegetation--reindeer moss and other lichens--which takes its nutrients directly from water interception, the quality of the air may be reflected sharply in the vegetation. Alaskan natives eating caribou and reindeer meat have been examined (Hanson, Palmer, and Griffin, 1966) and it was found that Cesium-137 body burdens were directly related to amounts of caribou or reindeer meat consumed. It would seem that the Arctic atmosphere is not a high capacity sink for pollutants.

The Arctic itself is probably in a precarious climate balance. A number of variables in its heat budget are quite sensitive and it is possible that relatively small changes in one or more may result in a dramatic adjustment to a different heat balance, i.e., climate change. There is much speculation and some work underway on this problem. It is not yet quite clear what scales are important; the most promising method seems to be mathematical modelling and computation of the effects of altering certain variables. It is important, however, that no deliberate attempt is made to put additional large-scale strain on the Arctic atmosphere before the results can be predicted with some confidence.

Radioactivity and Atomic Fall-out

Apart from the special conditions described in the previous section, the dangers from radioactivity, air-borne, in the Arctic are the same as for other areas. Unfortunately the reputation which the Arctic enjoys for remoteness and (in the past, at least) general worthlessness, has caused it to appear attractive to those powers and organizations that plan and carry out large-scale atomic experiments. This attractiveness it shares with large deserts and small distant islands. One such planned experiment, which in fact did not materialize, was the "Project Chariot" of the "Plowshare" Program developed in 1957 by the U.S. Atomic Energy Commission, designed to study and develop peaceful uses for nuclear explosives. Project Chariot was to make studies of experimental harbour excavation, and it was abandoned in 1962 because "much of the desired nuclear-excavation engineering data originally planned to be obtained in Chariot had become available or would become available from other experiments being planned" (Wilimovsky and Wolfe, 1966). A.E.C., however, had taken the precaution of setting up elaborate field studies to assess the effect of the proposed experiments on the environment, and "to assure that it could be conducted safely." The Committee established to make these studies had the following objectives, quoted from the same source (Wilimovsky and Wolfe, 1966):

1. To become sufficiently familiar with Arctic ecological systems in the project area to permit: (a) estimates of the biological cost of the excavation operation and (b) judgements as to whether or not there would be effects that could result in widespread damage or major disruption of ecological systems.

2. To become sufficiently familiar with the biological and physical environments that the findings could be used as base lines in studies to be conducted in post-excavation time.

3. To determine radiation levels and the distribution of radioisotopes in the bioto and physical environment in pre- and postdetonation time.

4. To conduct all studies in such a manner that the results

would constitute a significant contribution to scientific knowledge.

The preface to this enormous report on the Cape Thompson region points out that man has reached the stage of "geographical engineering," which is again emphasized in a later section in this present brief, and that "man now has the capacity to use technology in ways that are majestically massive in their scope, awesome in their speed of execution, and pause-giving in that their residues may be found around the earth and from pole to pole."

In this instance the atomic project gave rise to a remarkable valuable collection of field studies, physical, biological, and anthropological, presented in the Wilimovsky and Wolfe report. The same cannot be said for the "Cannikin" project on Amchitka, which at the moment of the writing of this brief is imminent. Atomic explosions of this size, anywhere in the world and no matter how deeply buried, cannot but cause the greatest concern to ecologists as to others; but the problem is by no means only an Arctic one and is therefore not given special attention here.

Industry and the Native Population

We make no apology for including this subject in a paper on the Arctic environment. The arrival of industry in the north will raise problems concerning the natural ecosystem, of which the native population may be considered to be, or have been, a part, and moreover it will directly alter the immediate human environment as a whole, and is already doing so. It is the latest chapter in the history of "Homo arcticus," in which the confrontation takes place between two very different phases of humanity, the Eskimo and the industrialist.

This is an old problem. It has appeared everywhere where industrial man has gone abroad into countries of an earlier stage of economic development, and it has usually been mismanaged, to the detriment of both industry and native population. It looks like being mismanaged in Arctic North America, unless we are careful and forewarned. To try to graft a native, ecologically based culture on to a developed industrial culture is to try to mix oil with water, to use a not inapt simile. The natives are usually called "lazy" by the other side, and as a rule the native population is too polite to say what they really think of the industrialists. To the man of industry, there is no doubt that if you pay a man a standard wage, you must expect him to be on the job from 9 to 5, or 8 to 4, and if it is suggested that this is not reasonable in the case of the Eskimos or Indians, he is puzzled and nonplussed. There are exceptions, and the exceptions are very important, but this seems to be the general rule.

Problems of this sort involve education, and education takes time. The years of natural scientific research in the north since

the second world war have done much to absorb the shock of the present environmental problems, but in matters of education we are in a state of near nudity in the North American Arctic. This is not the place to discuss education in the Arctic at length; all that can be done is to make two points: First, that the present educational policies, at least in Arctic Canada, seem ill-adapted to the problems at hand; and second, that not enough attention has been paid to the Greenland example, where schooling began in the first half of the 18th Century. It is true that education up to the present Greenland standard and practice can be done in much shorter time and more rapidly, but in North America we have in fact no time left at all. The solution to the problem in integrating the native population into the "new north" will require great patience and great understanding on both sides. They are an adaptable people, the Eskimos, and they learn fast, but we may be facing them with an urgency that may be too much even for them. The same is probably true of the Indians. Better schools and a University of the North would help enormously, but with a necessary time-lag.

Man the Geomorphic Force

Environmental damage is only one side of the coin; the other is environmental control and manipulation. Man is already altering the climate and conditions in which he lives on a fairly large scale (on a small scale he has been doing it for millennia), as when he controls the freshwater run-off into estuaries and other coastal regions, or increases the carbon dioxide content of the atmosphere, which he has been doing for several decades. Before long we shall be able to alter and control our climate and the productivity of both land and sea on an even larger scale, and in this kind of activity the northern regions will be very important, perhaps the key to the whole process. To take three examples, two possible, the third probably not possible: The Gulf of St. Lawrence, Hudson Bay, and the Arctic Ocean itself. All three illustrate the importance of the sea as the prime mediator of heat in the world.

Hans Neu of the Bedford Institute of Oceanography at Dartmouth, Nova Scotia, has drawn attention to what is going on in the Gulf of St. Lawrence. The control of freshwater inflow into the Gulf by hydro-electric plants is altering the natural flow of fresh water, so that the normal spring peak of land drainage is being spread over the whole year. This may be expected to have two effects: (1) reduction in the biotic production of the Gulf and (2) encouragement of heavier ice cover and longer period of ice cover. The natural outflow is greatest in the spring, and it entrains with it, in flowing over the Gulf, quantities of salt water which are replaced from deep layers below, causing upwelling and replenishment of the surface layer with the all-important nutrients. This spring upwelling, it must be supposed, would be reduced if the land run-off were held back (as it is now) and spread more or less evenly over the twelve months of the year. This altered pattern of run-off would

also give more fresh water at the surface than is natural during the fall and winter,thereby increasing the probability, and the extent, of the formation of ice.

Implicit also in the control of river flow is the formation of artificial lakes, which can completely disrupt the fishing economy over large areas of river systems, flood valuable land, and change the whole pattern of life for the population of the region. Decisions have therefore to be reached on the relative values involved, what is lost and what is gained by such operations; and it is urged that in the formation of these decisions more than the simple engineering and financial interests be consulted. Above all, expert and independent ecological opinion must be sought from the beginning of the planning stages. There is considerable concern at present, from the ecological and anthropological points of view, over the power development in the James Bay area, to give only one example.

Consideration has been given in the past to the possible beneficial effects to be achieved by damming the Strait of Belle Isle between southern Labrador and the northern tip of Newfoundland. It was pointed out many years ago that the climate of the Gulf of St. Lawrence region is continentally determined and "comes from the west," and that therefore the closing of the Strait of Belle Isle could have little or no effect. But more recent speculation and approximate arithmetic have raised this issue again, on the grounds that whereas the overall climatic effect would be insignificant, the dam would keep just sufficient heat in the surface water of the Gulf to make present heavy ice years lighter and light ice years lighter still, a result which economically would be by no means insignificant.

Most, perhaps all, of the Arctic water which flows into the vast inland sea of Hudson Bay comes through Fury and Hecla Strait between western Baffin Island and the mainland of Canada. This strait, through which flows something of the order of one-half Sverdrup (half a million cubic meters per second) of very cold water, is narrow and shallow, and there are islands in it, so that to dam the strait would not be an overwhelming engineering task. Closing it would either considerably reduce the circulation in Hudson Bay or draw into Hudson Bay water from Hudson Strait; if both occurred, the emphasis would probably be on the former effect. In any case the temperature of Hudson Bay would be raised somewhat and the time of freezing correspondingly delayed. This needs careful quantitative study. The effect would be enhanced if the land drainage were reduced by the diversion of rivers flowing into Hudson Bay, a possibility which has already been suggested in another context. The salinity of the surface layer, which at present is very low, would be raised, again tending to delay freezing. Furthermore, the vertical stability of the water column would be reduced, which would be expected to have a positive effect on the biotic productivity.

Ambitious and formidable although such schemes may appear, they are none the less coming within the power of humanity, and they must therefore be given serious and careful examination. Again, the profits and loss, in terms of human values, must be known and recognized before theoretical examination moves into practice.

Since the late 19th Century there have been Russian proposals to dam Bering Strait between Alaska and Siberia, through which about one Sverdrup flows northward into the Arctic Ocean, a quantity about two or three hundred times the flow over Niagara Falls. The intention has always been to remove the ice from the Arctic Ocean and "ameliorate" the climate of the north, perhaps of much larger areas. The plans have always been put forward by engineers and have promptly, each time, been quashed by meteorologists and oceanographers as both impossible and dangerous. They have been examined by various authors and are mentioned here only as an example of a scale of operation of which man is not yet capable, the results of which would be of very doubtful value indeed.

Natural Climatic Change

Climatic change in both the atmosphere and the hydrosphere has been very apparent in the north during the present century; particularly in the sea, natural climatic changes have had compelling economic effects in west Greenland, Iceland, and Svalbard. They have been carefully documented as they have occurred, but almost no attempt has been made to forecast them. In other words the documentation has not been detailed enough, which means that routine measurements, throughout the year and in all years, have been lacking. We are referring to the marine climate rather than the atmospheric climate, which is served by well-organized meteorological offices throughout the world. The liquid medium moves more slowly and has quite different heat characteristics, which make it a better guide to climatic cycles than the restless atmosphere can be. There has, however, been no organized routine of measurement in the sea and there is none yet; it is hoped that one result of the Stockholm Conference will be the planning of such an organization.

The history of recent marine climatic change is best known in the North Atlantic-Arctic region, where it appears to result from a shifting balance between Arctic and Atlantic water. The upswing in the sea temperatures in west Greenland from 1915 to about 1950 made possible an inshore cod and halibut fishery; the present decline in temperatures now threatens to destroy this most valuable Greenland resource. The extent of sea ice has changed during the same period, especially in the Iceland waters, where the movement and severity of ice conditions has been of first-rank economic importance during the whole millenium of the settlement of that country, being reflected even in its poetry. The Second Sea Ice Conference, held in Reykjavik in May 1971, passed a resolution

Requesting the National Research Council of Iceland, through diplomatic and other appropriate channels, to bring to the attention of States interested in the Arctic and States signatory to the Antarctic Treaty the need for:

(i) the standardization of techniques of observing, reporting, and recording sea ice phenomena;
(ii) the free international exchange of raw and processed sea ice data and for its storage in world data centres;
(iii) increased integration and co-ordination of research into sea ice problems along lines at present being planned or carried out by governments or under the auspices of the World Meteorological Organization, the Intergovernmental Oceanographic Commission, International Council for the Exploration of the Seas, the Scientific Committee on Antarctic Research, and the Scientific Committee on Oceanic Research;
(iv) an integrated programme of oceanographic and meteorological observations and research into the energy and water mass exchange processes through the seas peripheral to the Arctic Ocean, and, in particular, the Norwegian, Greenland, Iceland, and Irminger Seas in relation to the sea ice cover of the Arctic Ocean and the East Greenland Current;
(v) a co-ordinated sea ice observational and research programme in the Antarctic

in the hope that, where appropriate and feasible, they will support programmes, within the existing international scientific framework having these or similar ends in view.

This solemn climatic dance affects us all, and we are paying remarkably little organized attention to it.

There is a need for (a) a program of routine oceanographic measurement, organized internationally, of temperatures and salinities in certain key sections such as Hudson Strait, Davis Strait, the Labrador Sea, Denmark Strait, over the Wyville Thompson Ridge between Iceland and Scotland, and in the Barents Sea and Svalbard areas; between northeast Greenland and Svalbard; and (b) a broadly based investigation into the nature and causes of these events, whose causes may possibly reach beyond the global limits into our solar system as a whole, and whose effects certainly are world wide.

Montreal, November 1971

REFERENCES

Dunbar, M.J. 1971. Environment and Good Sense. McGill-Queen's University Press. Montreal and London: 92 pp.

Hanson, W.C., H.E. Palmer and B.I. Griffin. 1966. Radioactivity in northern Alaskan Eskimos and their foods, Summer 1962. In Environment of the Cape Thompson Region, Alaska, U.S. Atomic Energy Commission: pp. 1151-1164.

Kalff, J. Pigment cycles in two high Arctic Canadian Lakes. Verh. Int. Ver. Limnol., 18 (in press).

Passmore, R.C. 1970. Crisis in the North. Canadian Wildlife Federation.

Peterson, J.T. and L.D. Drury. 1967. Reduced values of solar radiation with occurence of dense smoke over the Canadian tundra. Geogr. Bull. 9: pp. 269-271.

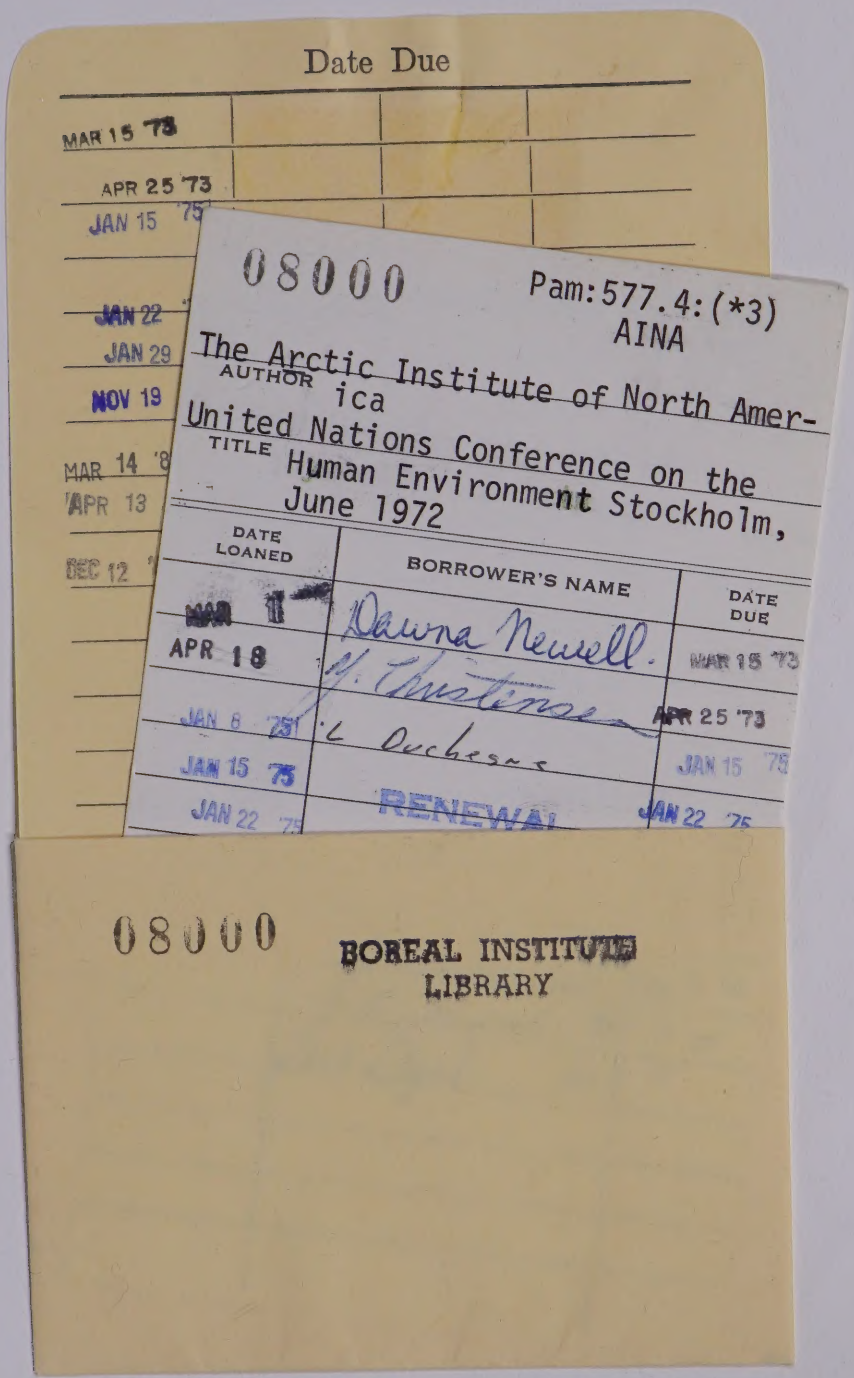
Rempel, G. 1970. Arctic terrain and oil field development. In: Fuller and Kevin (eds.), Productivity and conservation in northern circumpolar lands. Proc. Tundra Conference; IUCN Publ., n.s. No. 16: pp. 243-251.

Rigler, F.H. 1971. The Char Lake project. Proc. IBP-UNESCO Symposium on productivity problems of fresh water. Polish Acad. Science (in press).

Robinson, E. and C. Robbins. 1969. Atmospheric CO concentrations on the Greenland ice cap. J. Geophys. Res., 74: pp. 1968-1973.

Vowinckel, E. and S. Orvig. 1967. The inversion over the Polar Ocean. W.M.O. Tech. Note 87, T.P. 111: pp. 39-59.

Wilimovsky, N.J. and J.N. Wolfe (eds.). 1966. Environment of the Cape Thompson region, Alaska. U.S. Atomic Energy Commission: 1250 pp.



Date Due

MAR 15 '73
APR 25 '73
JAN 15 '75
JAN 22
JAN 29
NOV 19
MAR 14 '8
APR 13
DEC 12

08000 Pam:577.4:(*3)
AINA

AUTHOR The Arctic Institute of North America

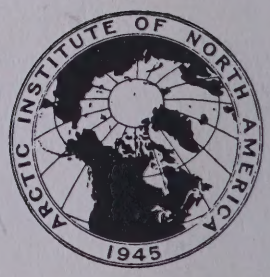
TITLE United Nations Conference on the Human Environment Stockholm, June 1972

DATE LOANED	BORROWER'S NAME	DATE DUE
MAR 1	Dawna Newell.	MAR 15 '73
APR 18	[illegible]	APR 25 '73
JAN 8 '75	L Duchesne	JAN 15 '75
JAN 15 '75	RENEWAL	JAN 22 '75
JAN 22 '75		

08000

BOREAL INSTITUTE
LIBRARY

University of Alberta Library
0 1620 0329 6744



Offices of the Institute

3458 Redpath Street, Montreal 109,
Quebec, Canada (Headquarters)
Office of the Executive Director,
Suite 2222, Tower A, Place de Ville,
Ottawa, Ontario, Canada K1R 5A3
1619 New Hampshire Ave., NW,
Washington, DC, 20009, USA

Representatives

Anchorage, Alaska;
Thule, Greenland; Whitehorse,
Yukon; Yellowknife, NWT